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On the Long Run Effects of Barriers to Trade*

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Abstract

We study the macroeconomic effects of international trade policy by integrating a Hecksher-Ohlin trade model into an optimal growth framework. The model predicts that an open economy will have higher factor productivity. Furthermore, under protectionist policies there may be "development traps," or additional steady state balanced paths with low income levels. Hence, the large cross-country differences in barriers to trade may explain part of the huge dispersion of per capita income observed across countries. The effects are quantified and show that protectionist policies can explain a significant fraction of TFP differentials, and a very large portion of the long run income differentials, across countries.

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1 Introduction

We study the effects of international trade policy on long run output levels, by merging a factor-endowment trade structure into the standard neoclassical growth model. Like in Corden (1971), Trejos (1992) or Ventura (1997) we do this by assuming two tradable and non-storable intermediate goods, used in the production of a non-tradable final good, and focusing on the case of a small, price-taking economy. These modelling choices imply that the potentially complex dynamic trade problem can be easily worked out sequentially: The solution of the static trade and factor allocation problem generates implicitly an aggregate mapping between factor endowments and final output, which can then be used as an exogenous production function in the dynamic problem. We calibrate the model, to assess the order of magnitude of the effects it predicts for trade policy.

Policy instruments that increase the cost of international trade generate an inefficient equilibrium allocation of factors across industries. In the model, this inefficiency has an effect similar to fall in total factor productivity. Even with conservative calibration of the parameters that determine the aggregate static importance of trade, so that its effects are negligible for rich countries, poorer countries get a much larger gain from trade. Indeed, the model says that for a country with 1/4 of US capital/labor ratio, the static difference between having tariff level of 10% or 100% can represent a loss of output of 8.7%. Applying the model to the data of some countries with a protectionist past, we find that as much as half of their TFP difference relative to the US can be attributed to restrictive trade policy.

Another result is that under certain conditions, trade policy instruments may generate a "selective development trap," in the sense that economies that start poor enough and apply protectionist policies may converge to balanced growth paths at relatively low income levels. It is important to note that the existence of multiple balanced growth paths for certain policy parameters does not depend on external effects or nonconcavities, but rather on the aggregate general equilibrium consequences of trade and of commercial policy distortions, under standard production and utility functions. Development traps can occur because trade barriers reduce not only the level of productivity, but also the marginal productivity of inputs. Hence, the protectionist country not only uses capital inefficiently, but also accumulates less of it in the long run. Under our calibration, an economy that starts out relatively poor and with a sustained generalized tariff rate of 75% will end up with 1/3 of the long run output that it could converge to under free trade or with a higher initial income. This result implies that this model can be used to understand disasters, while not predicting that all poor countries end up in disaster.

There is some empirical evidence that supports the two results mentioned above. Frankel and Romer (1999) find a relatively robust and potentially large relationship between openness and income levels. Hall and Jones (1999) also find that open trade policy (namely, low tariffs and low incidence of quotas and other non-tariff trade barriers) increases income per-capita both by enhancing capital accumulation and, notably, by expanding productivity. Evidence regarding the link between trade policy and convergence is provided in Ben-David (1993) and Papageorgiou (2001). The first author finds a strong relationship between the removal of trade barriers and the decrease in income disparity across countries in the European Economic Community while the second uses data-sorting methods to show that openness is a key variable to identify middle-income countries into high and low-growth groups. Likewise, Sachs and Warner (1995) show that among countries that are open to trade one cannot statistically reject convergence, while the same is not true in a broader sample of countries. Finally, O´Rourkeand Williamson (2000) show that, as trade barriers fell across the main Atlantic economies in the late XIX Century, there was among them significant convergence, which stopped and reversed as protectionist policies began to be implemented during and after the First World War.This findings suggest that relatively poor countries that choose isolationist trade policies set themselves up for development traps.[1]

Section 2 presents the model, and Section 3 derives the theoretical results. The calibration and quantification of the results is performed in Section 4. Section 5 concludes.

[1]One should mention that there is a broader literature regarding the link between international trade and other aspects of macroeconomic performance, using a variety of data and techniques. See for instance Rodriguez and Rodrik (2000), Krueger (1997), Edwards (1998), Harrison (1996), Lee (1996), Taylor (1996) and Dollar (1992). Previous empirical work on the same topic is also surveyed in Edwards (1993).

Most previous efforts to explain the link between trade and long run performance emphasize other motives for trade than comparative advantage. For instance, in Romer and Rivera-Batiz (1991) or Grossman and Helpman (1991) increasing returns is the key factor. Other papers study linkages –Rodriguez-Claire (1996)–, learning by doing –Young (1992) –, or the absorption of foreign technology –Holmes and Schmitz (1995).

2 The economy

Time is discrete and unbounded. Our representative country is populated by a continuum of identical, infinitely-lived individuals. There are three goods produced in this economy. Two of those goods, called A and B, are non-storable intermediate products. They are only used to make the other good, called Y, a final product that can be consumed or invested. There are also two factors of production in this economy: labor L and physical capital K. The endowment of labor, measured in efficiency units, grows at an exogenous rate μ, due to demographic expansion, exogenous schooling, and other forms of technical progress.

The technology is as follows: physical capital and labor can be used in the production of the intermediate goods A and B, with constant returns Cobb-Douglas technologies:

$$\begin{aligned} A &= K_A^{\alpha_a} L_A^{1-\alpha_a} \\ B &= K_B^{\alpha_b} L_B^{1-\alpha_b}. \end{aligned}$$

Without loss of generality, we assume that A is the labor-intensive good, so $\alpha_a < \alpha_b$. The production of the final good Y uses only the intermediate goods,[2]. Because these intermediate goods are tradable, the amounts of them that are used in the production of the final good (denoted by lowercase a and b) may differ from the amounts produced A and B. Total output of Y is given by:

$$Y = \Theta a^{\gamma} b^{1-\gamma}. \tag{1}$$

Final goods can be used in either consumption or investment. Capital follows the usual law of motion:

$$K' = (1-\delta)K + Y - C. \tag{2}$$

The representative consumer owns the capital, and faces the standard intertemporal maximization problem, with instantaneous log utility and discount rate denoted β. All markets are perfectly competitive. The ordinary market clearing conditions for both factors are

$$\begin{aligned} K &\geq K_a + K_b \\ L &\geq L_a + L_b \end{aligned}$$

[2] The results are not changed significantly if we assume that factors are also used in the production of final goods, and rewrite (1) as $Y = \Theta\left(a^{\gamma} b^{1-\gamma}\right)^{\eta}\left(K^{\alpha_y} L^{1-\alpha_y}\right)^{1-\eta}$.

Our economy is one of potentially many small "countries," that trade with each other and with one large country that we refer to as the *world economy*. The latter is large enough that prices in international trade are the same as the world-economy´s autarkic prices.

We assume that physical characteristics imply that only the intermediate goods A and B can be exchanged internationally. The international relative price of A in terms of B is denoted p. Also, the government may impose barriers to international trade, which here will be represented by a flat, ad-valorem tariff τ on imports, whose proceeds are transferred back to households. Because of these tariffs, the domestic relative price of A in terms of B may differ from p, and is denoted q. Factors, final output or any form of financial obligation cannot be traded. All markets that do exist are assumed to be perfectly competitive. The domestic prices of capital, labor and final output Y (again in terms of B) are denoted r, w and π.

It will be shown below that, under no trade, this model has a unique, globally stable balanced growth path with growth rate μ, a steady state for capital and output in per-labor units. We can assume that the world economy has already converged to said steady state. This also implies that p, which is pinned down by the capital-labor ratio of the world economy, denoted k^*, is constant.

3 Equilibrium

The model is designed so that the potentially complicated dynamic trade problem can be solved sequentially, using the following procedure to obtain equilibria. First, we derive the allocation of capital K and labor L among the production of A and B, the quantities a and b of intermediate goods used domestically, and the amount of final output Y that is produced. Because intermediate goods are assumed to be non-storable, and the final good is not tradable, this is a static problem, which yields an equilibrium mapping

$$Y = F(K, L|\tau, p)$$

that relates final output with factor endowments. Second, because factors are not tradable, we can simply use that equilibrium mapping F as if it were an exogenously given technology, so the dynamic problem that emerges as a result is standard.

Because all producers face a static problem[3], and the only goods tradable are not storable, the equilibrium conditions that govern the allocation factors and intermediate inputs in a given period can be written without reference to decisions in other periods. A period's equilibrium allocation is a combination of $\{A, B, a, b, \pi, q, w, r, K_i, L_i\}$ which satisfies that

1. Producers of intermediate goods choose K_i, L_i in order to maximize the period's profits:

$$\begin{aligned} \Pi_A &= \max_{K_A, L_A} qK_A^{\alpha_a} L_A^{1-\alpha_a} - wL_A - rK_A \\ \Pi_B &= \max_{K_B, L_B} K_B^{\alpha_b} L_B^{1-\alpha_b} - wL_B - rK_B \end{aligned}$$

2. Producers of final goods maximize profits, taking domestic prices as given:

$$a, b = \arg\max_{a,b} \quad \pi a^\gamma b^{1-\gamma} - qa - b$$

3. Firms make zero profits,

$$\begin{aligned} \pi a^\gamma b^{1-\gamma} &= qa + b \\ qA &= wL_A + rK_A \\ B &= wL_B + rK_B \end{aligned}$$

   markets clear,

$$\begin{aligned} K &= K_A + K_B \\ L &= L_A + L_B \end{aligned}$$

   and agents neither borrow from nor lend to the world economy,

$$pA + B = pa + b$$

4. Local prices of tradable goods satisfy an after-tariff law of one price:

$$q = \begin{cases} p/(1+\tau) & if \quad a < A \\ p \cdot (1+\tau) & if \quad b > B \end{cases}.$$

[3] The producer of an intermediate good faces every period a static problem, because in each period his only choice is to purchase inputs that are available in fixed quantity, in order to produce a good that cannot be stored. For him, there is no possible way to affect future profits with today's actions. Something similar happens with the producer of final goods Y.

From this conditions, one can solve for the value of Y as a function of parameters, prices and factor endowments, and thus derive the equilibrium relationship $Y = F(K, L|\tau, p)$. The algebra is cumbersome but straightforward, and is relegated to the Appendix.

Summing up what is important, it turns out that, for different capital/labor ratios, F takes different forms, depending on whether the economy is trading or not, which good is it exporting, and whether it is only producing that good or it is diversified. First, a country with very little capital per labor will specialize and only produce good A, trading some of it in the international market to acquire all the B that its Y producers need. In that case, the value of this output in the international market is proportional to the amount of A produced, and hence F will also be a Cobb-Douglas with capital coefficient equal to α_a. Second, a country with more capital per labor will diversify its production among A and B, but still be an A-exporter. In this circumstance, and for reasons that relate to the Factor Price Equalization Theorem that holds under diversification in the Heckshер-Ohlin model, it turns out that F is linear in K and L. Third, if the capital per labor is even higher, so that it is close enough to the one of the world economy, there will be no international trade. Roughly, this is because the difference between the local "autarkic" prices and international prices are not enough to compensate the cost of the tariff. In that case, F happens to be a Cobb-Douglas function, with a capital share that is an average of α_a and α_b. Even higher capital output ratios will yield a linear F for a diversified B-exporting country, and very high ratios will imply that the country only produces and exports B, again with a Cobb-Douglas technology with share α_b.

To be precise:

1. If $k = K/L$ is much lower [much higher] from the world´s ratio k^*, only the intermediate good A [B] will be produced, as its production uses more intensively the relatively abundant labor [capital]. Thus, there is a critical level $\widehat{k}_A < k^*$ [$\widehat{k}_B > k^*$] such that if $k \leq \widehat{k}_A$ then the country *only* produces A, [if $k \geq \widehat{k}_B$ then the country *only* produces B]. Then, Y is a Cobb-Douglas function of K and L, with capital share α_a [α_b]. Furthermore, the critical values $\widehat{k}_A$ and $\widehat{k}_B$ are sensitive to τ. In particular, with higher tariffs the economy is less prone to specialize, so $\partial\widehat{k}_A/\partial\tau < 0$ [$\partial\widehat{k}_B/\partial\tau > 0$], with $\widehat{k}_A \to 0$ [$\widehat{k}_B \to \infty$] as $\tau \to \infty$.

2. If k is neither too close nor too far from k^*, the economy will produce both intermediate goods, yet it will still trade. Then, due to Factor

Price Equalization, the equilibrium marginal returns of capital and labor are not sensitive to small variations in the factor endowment. Then, there exist $\widehat{k}_1 \in (\widehat{k}_A, k^*)$ $[\widehat{k}_2 \in (k^*, \widehat{k}_B)]$ such that Y is linear in K and L when $k \in (\widehat{k}_A, \widehat{k}_1)$ $[k \in (\widehat{k}_2, \widehat{k}_B)]$. The critical value $\widehat{k}_1$ $[\widehat{k}_2]$ is sensitive to τ. In particular, $\partial \widehat{k}_1/\partial \tau < 0$ $[\partial \widehat{k}_2/\partial \tau > 0]$. Also, $\widehat{k}_1 \to 0$ $[\widehat{k}_2 \to \infty]$ as $\tau \to \infty$, while $\widehat{k}_1 = k^*[= \hat{k}_2]$ if $\tau = 0$

3. If k is very close to k^* there is no trade at all. To be precise, if $k \in \left(\widehat{k}_1, \widehat{k}_2\right)$ then $a = A$ and $b = B$. Again, in this case Y is a Cobb-Douglas function of K and L, with a capital share $\overline{\alpha} = \gamma\alpha_a + (1-\gamma)\alpha_b$.

Hence, the equilibrium relationship from K and L to Y takes the form

$$F(K, L|\tau, p) = \begin{cases} \Omega_1 K^{\alpha_a} L^{1-\alpha_a} \text{ if } K/L < \widehat{k}_A \\ \Omega_2 K + \Omega_3 L \text{ if } K/L \in [\widehat{k}_A, \widehat{k}_1] \\ \Omega_4 K^{\overline{\alpha}} L^{1-\overline{\alpha}} \text{ if } K/L \in [\widehat{k}_1, \widehat{k}_2] \\ \Omega_5 K + \Omega_6 L \text{ if } K/L \in [\widehat{k}_2, \widehat{k}_B] \\ \Omega_7 K^{\alpha_b} L^{1-\alpha_b} \text{ if } K/L > \widehat{k}_B \end{cases} \tag{3}$$

where the values Ω_i are functions of parameters, and are affected by p and τ. The derivation of F is presented in detail in the Appendix. At this point, note that for a closed economy (be it an economy with a very large tariff rate τ, or the price-setting world economy), it is the case that $[\widehat{k}_1, \widehat{k}_2) = \Re_+$. Consequently, without trade our model simply collapses to one with the aggregate production function $F^*(K, L|\infty, p) = \Omega_4 K^{\overline{\alpha}} L^{1-\overline{\alpha}}$.

For all values of p and τ, F is homogeneous of degree one in K and L. Hence, we can rewrite it as $y = f(k|\tau, p)$, where $y = Y/L$ and $k = K/L$. It can be shown that f is a continuous function. Just like y is pinned down by k as the solution of a static problem, it is also the case that the consumption-investment decision of agents can be solved using standard methods, taking f as if it was an exogenously given (albeit peculiar) production function.

The function f is decreasing in τ (strictly decreasing if $k \notin [\widehat{k}_1, \widehat{k}_2]$), as the gains from trade in this economy is reflected in the quantity and mix of inputs that go into $a^\gamma b^{1-\gamma}$, and tariffs unambiguously reduce the gains from trade in the Hecksher-Ohlin model. Not only total output, but also the marginal output $\partial f/\partial k$ is affected by tariffs; in fact, it is even possible that $\partial f/\partial k$ turns negative for some values of k if τ is very large. Also, output is sensitive to the terms of trade. In particular, f is increasing in p if the economy is an exporter of good A (that is, if $k < \widehat{k}_1$) and decreasing in p if B is the export good (that is, if $k > \widehat{k}_2$). These relationships of f with τ and p are continuous.

The effects of tariffs on output are illustrated in Figure 1, where f is drawn for $\tau = 0$ and $\tau > 0$. Notice that, given k, the more open economy unambiguously obtains more output as $f(k|\tau > 0)$ is everywhere below $f(k|\tau = 0)$.

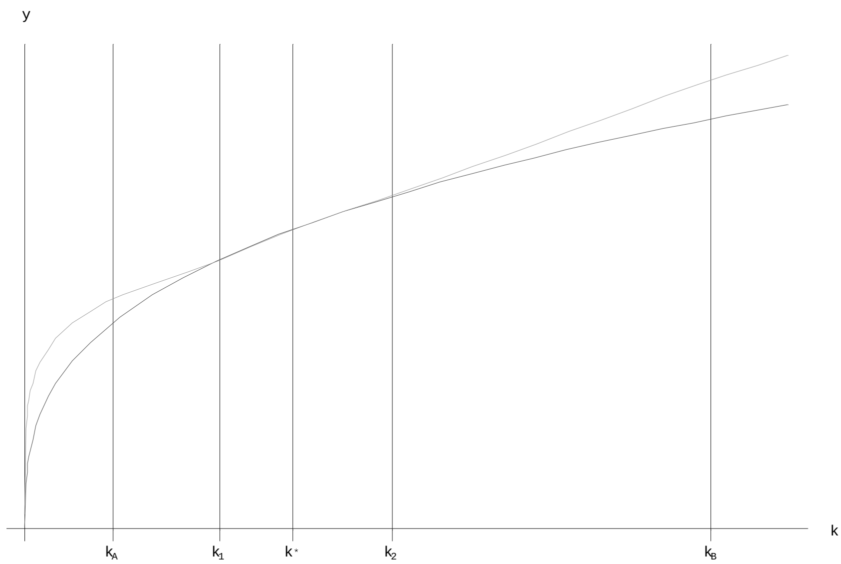

Figure 1: $f(k|\tau > 0)$ and $f(k|\tau = 0)$

Generically, f is locally concave and continuously differentiable, although, if $\tau > 0$ these properties do not hold globally. In particular, $f'(k)$ has discrete variations at the critical values $\widehat{k}_i$, so f is not globally continuously differentiable. Furthermore, at k_1 and k_2, $f'(k)$ discretely jumps *up*, and thus $f(k)$ is not globally concave either. This is illustrated in Figure 2.[4].

[4]Notice that at k_1, when $\tau > 0$ it is the case that $f(k|\tau, p)$ merges from above into $f(k|\infty, p)$. Hence, $f'(k_1^-|\tau, p) < f'(k_1^+|\tau, p) = f'(k_1|\infty, p)$. In other words, f' jumps up at k_1. A similar reasoning applies to k_2. The dashed line is $\frac{1+\mu}{\beta} + \delta - 1$ and this will be useful later.

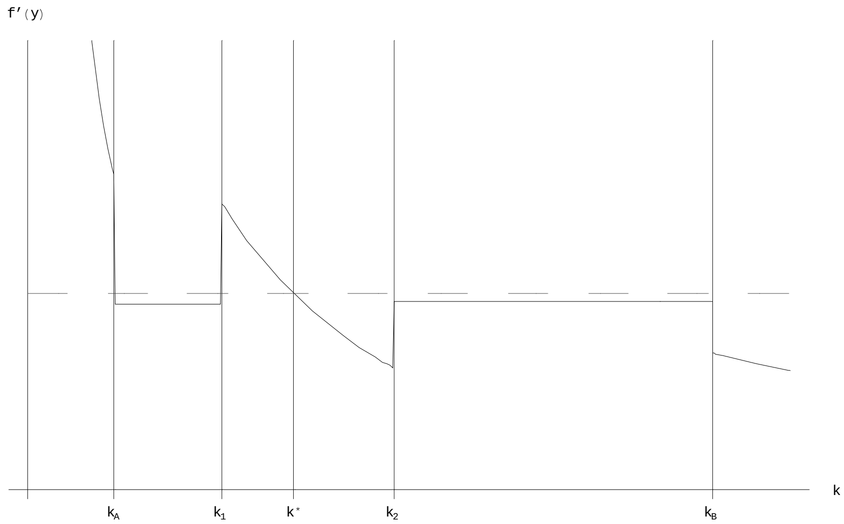

Figure 2: $f'(k|\tau > 0)$

Now consider the macroeconomics of an intertemporal model with an aggregate technology given by F. As seen above, for a given k, countries with more barriers to trade have lower output per labor. Hence, if the economy trades, and total factor productivity is estimated using a closed-economy aggregate production function, higher tariffs would correspond to lower measured total factor productivity in this model, as the gains from trade affect output. This is consistent with the empirical findings mentioned in the introduction. Why do tariffs reduce productivity? For two reasons, both completely standard within the Hecksher-Ohlin model of international trade. First, they distort the prices used in the decision of how to allocate the factors K and L between the intermediate goods production, a distortion that reduces the value of national product at international prices. Second, the same price distortion affects the ratio of the two intermediate inputs used by the final good producers, as the relative price they see, q, is not the same as the actual opportunity cost posed by the international market, which is the price p.

One should point out that the effect of tariffs on output is not uniform. As a fraction of output, the amount of trade is bigger for a country with k very different from k^*. This is because world prices p are pinned down by k^*; a country with very low k will have very low p if in autarky, and hence large potential benefits from exploiting its comparative advantage by specializing in A. Hence, for a wealthy country with its k close to the "world" k^*, even the static gains from trade are not very important, but the opposite is true for a country where capital is scarce, and where much can be lost due to barriers to trade.

Now, consider the dynamic problem of an economy with technology F. Recall that barriers to trade, in this model, affect not only the level of output but also the marginal productivity $f'(k)$. This means that the long run differences in output caused by tariffs are larger than the static losses mentioned above, as the capital/labor ratio along the balanced growth path is also affected by τ. Furthermore, even the global concavity of $f(k)$ is lost when $\tau > 0$. Therefore, as we shall see, the qualitative properties of the set of balanced growth paths may also change. This can occur even though all the production functions in the model are concave and homogeneous of degree one. The distortions implied by policy are the ones that change the aggregate equilibrium technology, and generate these results.

Usual derivations, assuming log utility, lead to the Euler equation $\psi(k, k', k'') = 0$, where

$$\begin{aligned}\psi(k, k', k'') &= [f(k') + (1-\delta)k' - (1+\mu)k''] - \\ &\quad \beta/(1+\mu)\,[f(k) + (1-\delta)k - (1+\mu)k']\,[f'(k) + 1 - \delta]\,,\end{aligned} \tag{4}$$

which characterizes the law of motion of k. We know that any *stable* balanced growth path (steady state in k) will be characterized by a capital-labor ratio $\widetilde{k}$ that satisfies

$$\begin{aligned}\Gamma &< f'(\widetilde{k}_-) \\ \Gamma &> f'(\widetilde{k}_+)\end{aligned} \tag{5}$$

where $\widetilde{k}_-$ and $\widetilde{k}_+$ are the limits as $k \to \tilde{k}$ from below and above, and where $\Gamma \equiv \frac{1+\mu}{\beta} + \delta - 1$. Notice that (5) is written in this way rather than in a single equation, since the global concavity of f is not guaranteed, and at some steady state candidates $f'(k)$ may not be well defined. In other words, (5) allows for steady states at the critical values $\widehat{k}_i$. The following proposition characterizes the set of steady states.

Proposition 1 *For all $\tau > 0$ there are two locally stable balanced growth paths. One of them is invariant in τ, and with capital-labor ratio k^*. The other one has a lower capital-labor ratio, given by $\widehat{k}_A$, which is decreasing in τ.*

Proof. First, recall that for all practical purposes the world economy does not trade, and its production function is $f^*(k) = \Omega_4 k^{\overline{\alpha}}$, the same as our small economy's in an interval $[\widehat{k}_1, \widehat{k}_2]$ that contains k^*. Therefore, as k^* satisfies (5) for the world economy, it must also satisfy the same condition for the small economy, and thus constitutes the capital-labor ratio along a balanced growth path. Furthermore, it is the case that

$$\Omega_1 \alpha_A \hat{k}_A^{\alpha_A - 1} > \Gamma > \Omega_2 \tag{6}$$

which implies that $\widehat{k}_A$ satisfies (5), and it is the capital labor ratio along a balanced growth path as well. Also, (6) implies that there are no other $k \in (0, \hat{k}_A)$ or $(\hat{k}_1, \hat{k}_2)$ that satisfy (5), as $f'(k)$ is strictly decreasing in those intervals. Also, no k in the intervals where f is linear satisfy (5), nor any values $k > \hat{k}_B$ since one can show that $\Gamma > \Omega_5$. Hence, there are no other balanced growth paths besides those with capital labor ratios $\widehat{k}_A$ or k^*. ■

The proposition states that for any tariff level there is a development trap, in which countries will fall if they start poor enough. The "trap" is a balanced growth path with lower k and y than the world economy. As $\hat{k}_A$ is decreasing in τ, the more protectionist an economy, the poorest it will be in the long run if it falls in the trap. Also, the trap is selective: if two countries start with the same initial capital/labor ratio, but different τ, it is possible that only one of them falls in the trap, while the other converges to the world k^*.

This is consistent with the finding that one cannot statistically reject convergence among countries with low barriers to trade, while countries with high barriers fail to converge, and tend to stagnate at lower levels of capital and output. A very open economy will enjoy high levels of capital and output, even if it falls in the trap . Meanwhile, when a high-tariff country falls in the trap, it is at low levels of inputs and of productivity. This is also consistent with the finding that trade barriers can be used to identify middle income countries into high and low growth groups.

Moreover, the model also allows for the possibility that even a initially very poor country avoids the traps altogether, and it always converges to the high balanced growth path. To be specific, if one allows for small deviations of the baseline parameters, if the small country has a slightly lower value of Γ than the world economy, then there exists a value τ_0 such that, if $\tau < \tau_0$, the trap does not exist and a slightly higher k than k^* is the unique steady state. Hence, a country that is marginally more thrifty than others and is not too protectionist will catch up with the rest of the world; other countries may stagnate at lower levels of output if they impose large enough tariffs.

4 Quantification

In this section we try to quantify the order of magnitude of the effects of introducing trade into the basic growth model. Recall that, in the larger world economy, which is in autarky for all practical purposes as trade is negligible, the equilibrium determination of final good output per efficiency unit of labor is $y = \Omega_4 k^{\overline{\alpha}}$. We interpret that world economy to be the US. So, we pick parameters as to mimic the common calibration of the American economy in RBC closed economy models. The same parameters will then be applied to our small open economy. That leads us to pick the parameters δ, μ and β that would generate annually without trade a 2% per-capita growth, 6.1% net return on capital, and a 2.75 capital/output ratio along the balanced growth path. This implies that $\delta = 0.06$, $\mu = 0.04$ and $\beta = 0.9802$. The share of capital is conventionally picked to be $\overline{\alpha} = 1/3$. For lack of information on the parameter γ, we opt for symmetry and chose the value 1/2. The chosen value of γ does not affect the results much, provided that one adjusts the other parameters to maintain the value of $\overline{\alpha}$.

The standard closed-economy calibration pins down the average $\overline{\alpha}$, but leaves freedom in choosing α_a and α_b. The choice of these two parameters is important, as the quantitative effects of all trade-related phenomena are bound to be larger with a big spread $\alpha_b - \alpha_a$, leaving $\overline{\alpha}$ constant.[5] One way to discipline the choice of parameters is by picking α_a and α_b conservatively to match the relatively small estimations in the literature about the size of gains from trade in high income countries. We choose parameters so that in 1985, for a country with the capital-labor ratio of Spain (the world's 20th richest country at that time), the total gains from trade in passing from $\tau = \infty$ to $\tau = 0$ would have amounted to only 1% of total output.[6] This leads

[5] For instance, Ventura (1997) demonstrates that one can even get endogenous growth by assuming $\alpha_a = 0$, $\alpha_b = 1$. On the other hand, there is no trade at all under any circumstances if $\alpha_a = \alpha_b$. All the action here happens because our α_i are between those extremes, but the precise choice is important. If both industries demand, given prices, very different capital labor ratios, there is much to be gained from trade for a country with a distinct k, as it can specialize strongly on the industry whose demand is closest to their endowment.

[6] In the survey by Kehoe and Kehoe (1994) it is argued that most estimates of the

to $\alpha_a \approx 0.258$ and $\alpha_b \approx 0.408$. While trade is negligible for the wealthier countries, this calibration predicts larger effects as k falls. These parameters imply that total static gains from trade (that is, the whole output difference in going from $\tau = \infty$ to $\tau = 0$) are 5.7% of GDP for a country as capital poor as Mexico, 8.3% for Brazil and 10% for Costa Rica.

Under those parameters, consider first the static effect of tariffs on measured productivity. Figure 3 shows proportionately how much higher productivity would be with $\tau = 2.5\%$ than with $\tau = 50\%$, as a function of the stock of physical capital (relative to k^*), leaving all else constant.

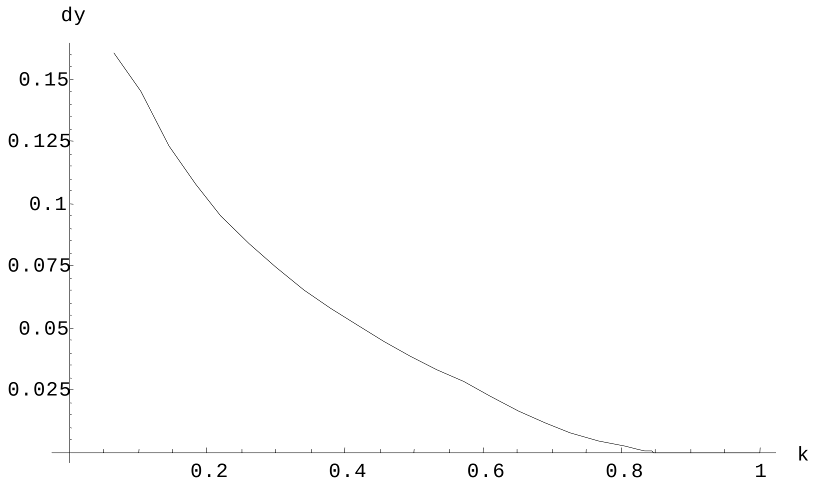

Figure 3: Productivity differences as function of inputs $\left(\frac{\tau=2.5\%}{\tau=50\%}\right)$

We can see that, while for rich enough countries the difference is negligible, for the world's poorest countries these two policies yield productivity levels that differ in as much as 17%. The contrast in tariffs in the graph is in line with what we see in many places. In fact, protectionism for many developing nations between the 60's and 80's was very high, frequently with tariffs around 100%, as documented below.[7]

effect of NAFTA reflect negligible impact for the US and Canada, and only 2.2 percent of GDP for Mexico, in a static, applied general equilibrium model. Considering that NAFTA does not imply a change from autarky to irrestricted free trade, but rather a much smaller change in effective protection, our callibration is conservative even according to their results. It also yields negligible effects of trade for the richest countries.

[7] The callibration predicts important static effects in productivity for the many Latin American countries that have undertaken trade liberalization in the last few years. For instance, Ferreira and Rossi (2001) report that Brazil took average nominal tariffs from

We now study the magnitude of the development traps discussed in Proposition 1. Assuming no difference in parameters or in other determinants of productivity between the world economy and our small economy, both have a common high steady state at k^*. What we ask is how big are the differences in output per labor between the two steady states (between an economy that has fallen in the trap and one that has converged to the higher balanced growth path), and the sensitivity of those differences to τ.

We find that for low tariffs the gap is actually fairly small. At $\tau = 0$, income at the lower steady state is 90% of income at the higher steady state. As τ increases, however, the gap widens. At $\tau = 40\%$, income is just half in the trap than at the high steady state; at $\tau = 100\%$, one quarter. This is illustrated in Figure 4.

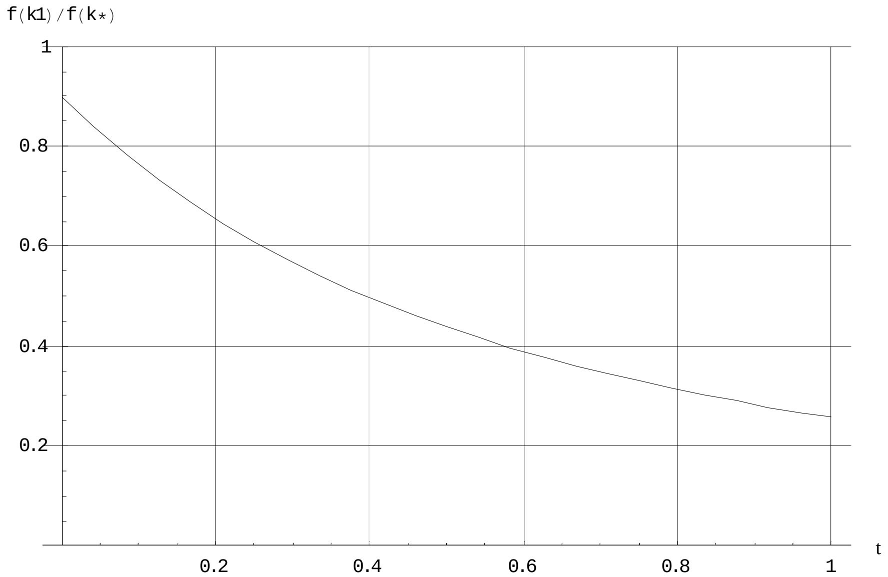

Figure 4: Relative output levels (development trap/high steady state) as function of tariffs.

If anything, the predicted effects of tariffs in the model seem to be too big compared to what the data show. The model predicts that pre-reform Costa Rican tariffs yield a trap at roughly pre-reform Costa Rican income, even if

112% to 13% in the early 1990's. This would imply a jump in productivity of 8% just through efficiencies in international trade. Indeed, industry measures of Brazilian TFP has soared in the 1990's according to the same authors.

with the same TFP as the US; with the actual Costa Rican productivity, the predicted income would be too low.

To close this section, we perform a level-accounting exercise for a variety of countries, to see what fraction of the total factor productivity residual that one measures using a closed-economy framework can actually be attributed to the inefficiencies associated with protectionist trade policy. We find that for many countries the effect of trade policy is negligible, because they have low tariffs, or because they are relatively wealthy compared to the US. Similarly, for many extremely poor countries, the effects of tariffs are large compared to their own low income, but only a very small fraction of their productivity difference with respect to the US, which is also very large. Nevertheless, for some middle income economies with high tariff rates, the effects are significant; in some cases, enough to attribute to protectionism half of their TFP disadvantage, or more.

So far, we have avoided the topic of human capital altogether, simply by assuming that labor is measured in efficiency units. Income disparities across countries are largely explained by differences in human capital, as many authors have shown, such as Mankiw, Romer and Weil (1992) or Klenow and Rodriguez-Claire (1997), . Therefore, in what follows, we perform our cross-country comparisons using $y = F(k, h|\tau)$, where y is output per worker, k is capital per worker, and h represents efficiency-units of labor per worker. To assess h, we use a standard Mincer function of schooling, of the form $h = \phi(s) = e^{\gamma s}$. Following Psacharopoulos (1994), we use a return of schooling of $\gamma = 0.099$.

We use Summers and Heston (1991) data for output per worker, and to generate capital per worker using perpetual inventory methods. For s, we use the years for schooling as reported in Barro and Lee(1996). Finding comparable data across countries for tariff rates, however, is harder.[8]

As illustration of the effects of protectionism, Tables 1 and 2 show comparisons with the US for some countries in the mid 1960's and mid 1980's, respectively, for which careful measurements of protectionism, converted into τ-

[8] Some countries report average tariffs across all products, but this gives a low estimate of τ since exportables usually carry no tariffs in the law. Other countries report weighted averages using traded volumes as weights. This again is biased as products with prohibitive rates are not traded. Finally, data for tariffs is more commonly available than for other policy instruments that are equally restrictive of trade, like quotas, that are extensively used.

equivalent terms, are available.[9] The column labelled y shows log-differences in output relative to the US, and the columns labelled s, k, τ and Θ are the portion of those log-differences that can be attributed to schooling, capital, protectionism and productivity, respectively. They should, of course, add up to the value shown in column y. The last column measures the proportion of total residual $(\tau + \Theta)$ explained by tariff distortions alone.

Table 1: Differences in output relative to the US, mid 1960's

	y	s	k	τ	Θ	$\tau/(\tau+\Theta)$
Chile	1.01	0.207	0.385	0.068	0.355	16.0%
Brazil	1.58	0.326	0.608	0.058	0.592	9.0%
Pakistan	2.26	0.431	1.23	0.027	0.569	4.6%
Philippines	2.13	0.249	1.14	0.022	0.726	2.9%

Table 2: Differences in output relative to the US, mid 1980's

	y	s	k	τ	Θ	$\tau/(\tau+\Theta)$
Costa Rica	1.31	0.329	0.65	0.043	0.285	13.0%
Brazil	1.12	0.435	0.540	0.076	0.072	51.3%
Ivory Coast	1.96	0.46	1.54	0.061	0.228	21.0%
Thailand	2.29	0.339	0.963	0.032	0.628	4.9%

We can see that the loss of output due to tariffs is significant in some cases, especially for the middle-income countries; in Brazil for the 1980's, this was more important than all other causes of TFP difference combined as τ in this case explains 51.3% of TFP difference with respect to the US.

5 Conclusion

In this paper, we have studied a model that integrates a simple Hecksher-Ohlin trade structure into a dynamic optimal growth model. The main theoretical results are that barriers to international trade reduce the total factor productivity of an economy and can cause the existence of development traps, or low-income steady states. We then calibrate the model, to get an idea of

[9]The source for protection rates for Table 1 is Balassa (1971). For Table 2, Ferreira and Rossi (2001) for Brazil, Gonzalez-Vega and Monge (1995) for Costa Rica, Harrison (1994) for Ivory Coast, and World Bank (1993) for Thailand.

the possible order of magnitude of the effects of trade policy on macroeconomic performance. We find that the aggregate effects of trade barriers can be large, in productivity and in long run output levels.

Exploiting comparative advantages generated by factor endowments is not the motive for most international trade, but it is the main motive of international trade for most countries. As Stiglitz (1998) mentions, we seem to understand better the static welfare effects of this kind of trade than what it does to productivity. Because in our model what is exchanged is intermediate goods, the gains from trade show up in production, not as consumption gains. Hence, even within a Hecksher Ohlin framework can trade have aggregate implications.

Following Parente and Prescott (1994), many researchers have attempted to explain cross-country income disparities as the steady state income disparities emerging from measurable differences in parameters across countries, within the neoclassical model. The motivation for this search is that many poor countries behave as if in a balanced growth path, with a very stable relationship between their income and that of the wealthiest countries, (see Figure 5). It does not seem as if these countries are catching up, but more like as if they have converged. The problem is that, by applying reasonable differences in parameters across countries, one can not explain but a small portion of these countries' poverty. Something needs to be added to the neoclassical model to solve the puzzle. Isolation from international trade is one candidate reason why so many nations stagnate at such poor relative income levels. One feature that countries stuck at very low incomes seem to share is a high level of protectionism. Our model relates these two features.

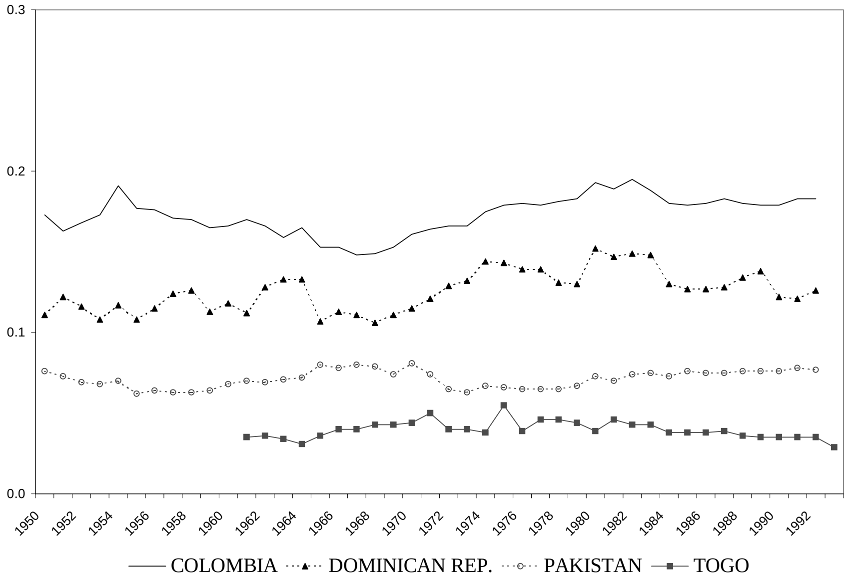

Figure 5: Income per capita relative to the US

Unlike most models in this literature, the one in this paper predicts that there may be multiple balanced growth paths to which an economy may converge. It shall be stressed that this does not come from assuming non-convexities in the technologies or preferences in the economy; every production function is concave and CRS. The multiplicity of steady states, instead, comes from the nature of the equilibrium relationships in a trading economy, under the distortion of import taxes. This multiplicity allows parameter differences across countries a double explanatory effect: not only they generate income disparities *within* a steady state, but also *across* them. If one can interpret rich countries as being in the high steady state, and at least some poor countries as being in the low one, in a model that, by explicitly modelling trade and trade barriers allows multiple stable steady states, the income disparities that can be explained with a given difference in fundamentals can be much larger. Hence, the model can generate very significant long run differences in income for apparently similar countries. If anything, the effects measured above seem to be too large relative to the task.

It is important to note that the "development traps" in our model are selective. Not all countries that start very poor will end up being very poor. Two nations with similar initial conditions but different policy will converge to different output levels, even if they both fall in the trap. In fact, if one considers that countries may differ from each other in other features besides policy and initial capital stocks, the model allows for the possibility that, under some parameter values, the lower steady state will not exist at all if the economy is open enough. It is important to understand that trade policy has dynamic implications.

As O´Rourke and Williamson (2000) note, the forces that are enhancing trade across countries are not necessarily permanent, as similar events before (the expansion of trade due to the fall of communication and transportation costs in the late XIX Century) have been reversed by protectionism and policy-imposed trade barriers. Whether or not we see world convergence in the long run may depend on this.

Because trade policy can change dramatically in a very short period, it is a good explanation for certain successes and disasters. Among the latter, Argentina is a salient case. While its income per person remained at around 70-80% of the US' in the first decades of the century, it started falling behind, to stagnate at around half that much after WWII. Notably, Argentina went from being very open to trade in the earlier period, to very protectionist for a long time after the war. Our model predicts that it takes tariffs to jump from 10% to 65% for the income at the development trap to vary in these amounts, a prediction that is in line with the data. A similar observation can be made about countries who caught up significantly following trade liberalization, after long periods of relative stagnation. Examples of this are South Korea after the 1970's and India in the 1990's.

A The production function

.We present in details the derivation of the production function used in the paper.

The profit maximization problems in the definition of stationary equilibrium yield six first order conditions, which can be simplified into:

$$\begin{aligned}
\frac{(1-\alpha_a)}{\alpha_a}k_A &= \frac{(1-\alpha_b)}{\alpha_b}k_B \\
\theta(1-\alpha_a)k_A^{\alpha_a} &= (1-\alpha_b)k_B^{\alpha_b} \\
\frac{\gamma b}{(1-\gamma)} &= \theta,
\end{aligned}$$

where θ is the local relative price of A in terms of B. Similarly, the market clearing conditions for K and L can be transformed into:

$$\lambda k_A + (1-\lambda)\, k_B = k,$$

where $\lambda = L_A/L$ and the production functions then written as

$$A = \lambda L k_A^{\alpha_a} \text{ and } B = (1-\lambda)\, L k_B^{\alpha_b}.$$

As reference, it shall be useful to consider first the case of an economy that cannot trade at all, and therefore in which the condition $pa + b = pA + B$ is substituted instead for the conditions $a = A, b = B$. In that case, the above solves into

$$\lambda = \gamma \frac{(1-\alpha_a)}{1-\bar{\alpha}},$$

where $\bar{\alpha} = .\gamma\alpha_a + (1-\gamma)\,\alpha_b$.Then, more algebra yields the solutions:

$$k_A = \frac{\alpha_a}{(1-\alpha_a)} \frac{1-\bar{\alpha}}{\bar{\alpha}} k \text{ and } k_B = \frac{\alpha_b}{(1-\alpha_b)} \frac{1-\bar{\alpha}}{\bar{\alpha}} k.$$

These then imply that total output Y (under $a = A, b = B$) can be shown to be:

$$Y = \Omega_4 K^{\overline{\alpha}} L^{1-\overline{\alpha}}, \tag{7}$$

where

$$\Omega_4 = \frac{\gamma^\gamma (1-\gamma)^{1-\gamma} \left[\alpha_a^{\alpha_a} (1-\alpha_a)^{1-\alpha_a}\right]^\gamma \left[\alpha_b^{\alpha_b} (1-\alpha_b)^{1-\alpha_b}\right]^{1-\gamma}}{\bar{\alpha}^{\bar{\alpha}} (1-\bar{\alpha})^{1-\bar{\alpha}}}.$$

Prices under no trade will always be

$$\theta = \theta(k) = \frac{{\alpha_b}^{\alpha_b} (1-\alpha_b)^{1-\alpha_b}}{{\alpha_a}^{\alpha_a} (1-\alpha_a)^{1-\alpha_a}} \frac{1-\bar{\alpha}}{\bar{\alpha}} k^{\alpha_b - \alpha_a}$$

It is standard that if world prices (that is, $\theta(k^*)$, where k^* is the capital-labor ratio of the world economy) are close enough to local autarkic prices, the economy will not trade. To be precise, if $k < k^*$ and $\theta(k^*)/\theta(k) < 1+\tau$, or if $k > k^*$ and $\theta(k)/\theta(k^*) < 1+\tau$, then there is no trade at all, and Y will follow equation (7). The values $\widehat{k}_1$ and $\widehat{k}_2$ are defined precisely by $\theta(k^*)/\theta(\widehat{k}_1) = 1+\tau$ and $\theta(\widehat{k}_2)/\theta(k^*) < 1+\tau$.

Therefore, when k is close enough to k^*, the production function is equal to the one for the non-trading economy. What happens when k is not that close to k^*? Assume that there is trade, and our country has comparative advantage in a (that is, $\theta(k^*)/\theta(k) > 1+\tau$). We solve the problem in two steps. First we solve for the allocation of K and L across A and B, to determine total output of intermediate goods, and then the international value of that output, or $Q = pA + B$. Once we do that, we can use the profit maximization problem for Y producers and the constraint $Q = pa + b$ to determine final output.

We must first determine the allocation of factors K and L across the two intermediate goods industries. From the first order conditions of the profit maximization for those firms, it is straightforward to derive the diversification cone of this economy, as given by the capital-labor ratios

$$\left[\frac{p}{1+\tau}\left(\frac{\alpha_a}{\alpha_b}\right)^{\alpha_b}\left(\frac{1-\alpha_a}{1-\alpha_b}\right)^{1-\alpha_b}\right]^{\frac{1}{\alpha_b-\alpha_a}} = s_1 \tag{8}$$

$$\left[\frac{p}{1+\tau}\left(\frac{\alpha_a}{\alpha_b}\right)^{\alpha_a}\left(\frac{1-\alpha_a}{1-\alpha_b}\right)^{1-\alpha_a}\right]^{\frac{1}{\alpha_b-\alpha_a}} = s_2$$

Notice that, under the assumption that b is the capital intensive good

$$\frac{s_2}{s_1} = \left(\frac{\alpha_b}{\alpha_a}\right)\left(\frac{1-\alpha_a}{1-\alpha_b}\right) > 1$$

As standard in the Hecksher-Ohlin model, the relative price of the intermediate goods (pinned down by international prices and tariffs) determine these critical capital-labor ratios s_1 and s_2. Then, if $k < s_1$, locally only A but no B will be produced. In this case, $A = K^{\alpha_a}L^{1-\alpha_a}$ and $Q = pA$. If $s_1 < k < s_2$, both goods will be produced, all A producers will pick $k_A = s_1$, and all B producers will pick $k_B = s_2$. Then,

$$K_A = s_1 L_A \qquad L_A = \tfrac{s_2 L - K}{s_2 - s_1} \qquad L_B = \tfrac{K - s_1 L}{s_2 - s_1}$$

imply

$$K - K_A = s_2\left(L - L_A\right) \qquad K_A = s_1\tfrac{s_2 L - K}{s_2 - s_1} \qquad K_B = s_2\tfrac{K - x_1 L}{s_2 - s_1}$$

Under these inputs, then, total Q is given by :

$$Q = L\frac{p s_1^{\alpha_a} s_2 - s_2^{\alpha_b} s_1}{s_2 - s_1} + K\frac{s_2^{\alpha_b} - p s_1^{\alpha_a}}{s_2 - s_1}$$

Therefore, if $s_1 < k < s_2$, Q is a linear function of inputs.

Now, solve for Y as a function of Q. Notice that a and b must satisfy

$$pa + b = Q \qquad \textit{and} \qquad \frac{\gamma}{1-\gamma}\frac{b}{a} = \frac{p}{1+\tau}$$

Solving for these equations and substituting into the Y production function, we get:

$$Y = \gamma^{\gamma} (1-\gamma)^{1-\gamma} p^{-\gamma} Q \frac{(1+\tau)^{\gamma}}{1+\gamma\tau} \tag{9}$$

Hence, final output is linear in Q.

Merging these results together, we find that when capital is low enough that no B is produced, then

$$Y = \gamma^{\gamma} (1-\gamma)^{1-\gamma} p^{1-\gamma} K^{\alpha_a} L^{1-\alpha_a} \frac{(1+\tau)^{\gamma}}{1+\gamma\tau} \tag{10}$$

Alternatively, if both goods are produced, and A is exported, then

$$Y = \gamma^{\gamma} (1-\gamma)^{1-\gamma} p^{-\gamma} \frac{(1+\tau)^{\gamma}}{1+\gamma\tau} \left[L \frac{p s_1^{\alpha_a} s_2 - s_2^{\alpha_b} s_1}{s_2 - s_1} + K \frac{s_2^{\alpha_b} - p s_1^{\alpha_a}}{s_2 - s_1} \right] \tag{11}$$

Similar procedures can be applied for the country with comparative advantage in b. Then, a and b satisfy:

$$pa + b = Q \qquad \textit{and} \qquad \frac{\gamma}{1-\gamma} \frac{b}{a} = p\,(1+\tau)$$

This implies

$$Y = \gamma^{\gamma} (1-\gamma)^{1-\gamma} p^{-\gamma} Q \frac{(1+\tau)^{1-\gamma}}{1+(1-\gamma)\tau}$$

Again, there are two relevant sub-cases here. One can derive another diversification cone (analogous to the one above, but with $p/(1+\tau)$ substituted for $p(1+\tau)$ in the expressions for s_1 and s_2), and it now holds that if k is too high, then

$$Y = \gamma^{\gamma} (1-\gamma)^{1-\gamma} p^{-\gamma} \frac{(1+\tau)^{1-\gamma}}{1+(1-\gamma)\tau} K^{\alpha_b} L^{1-\alpha_b} \tag{12}$$

On the other hand, for the diversified case

$$Y = \gamma^{\gamma} (1-\gamma)^{1-\gamma} p^{-\gamma} \frac{(1+\tau)^{1-\gamma}}{(1+(1-\gamma)\tau)} \left[L \frac{p z_1^{\alpha_a} z_2 - z_2^{\alpha_b} z_1}{z_2 - z_1} + K \frac{z_2^{\alpha_b} - p z_1^{\alpha_a}}{z_2 - z_1} \right] \tag{13}$$

It is straightforward to show that Y is continuous in K and L, as the curves (7), (10), (11), (12) and (13) intersect precisely at the values $\widehat{k}_1$, $\widehat{k}_A$, $\widehat{k}_B$, $\widehat{k}_2$.

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